



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>



HARVARD UNIVERSITY.



LIBRARY

OF THE

MUSEUM OF COMPARATIVE ZOOLOGY

42,249

GIFT OF

Author

March 25, 1915.

GARLORD BROS.
MAHERS
SYRACUSE, N.Y.

U. S. DEPARTMENT OF AGRICULTURE.

THE GEOGRAPHIC DISTRIBUTION OF ANIMALS
AND PLANTS IN NORTH AMERICA.

BY

C. HART MERRIAM,

Chief of the Division of Ornithology and Mammalogy.

[Reprinted from the Yearbook of the U. S. Department of Agriculture for 1894.]



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1895.

C O N T E N T S.

	Page.
Importance of a knowledge of the geographic distribution of species	203
An experimental biological survey	204
Provision for a systematic biological survey	206
The Death Valley Expedition	206
Correlation of the life zones	207
Recent field work	208
The seven life zones of North America	209
Fundamental principles of animal and plant distribution	211
Recapitulation	213

I L L U S T R A T I O N.

	Page.
Fig. 20. Map showing life zones of the United States	210

III

THE GEOGRAPHIC DISTRIBUTION OF ANIMALS AND PLANTS IN NORTH AMERICA.¹

By C. HART MERRIAM,

Chief of the Division of Ornithology and Mammalogy, U. S. Department of Agriculture.

IMPORTANCE OF A KNOWLEDGE OF THE GEOGRAPHIC DISTRIBUTION OF SPECIES.

An accurate knowledge of the areas which, by virtue of their climatic conditions, are fitted for the cultivation of particular crops is of such obvious importance to agriculture that the Division of Ornithology and Mammalogy was early led to make a special study of the geographic distribution of the land animals and plants of North America; for the boundaries of areas inhabited by native species were believed to coincide with those suited to the production of particular kinds of fruit, grain, and tubers, and for the rearing of particular breeds of domesticated animals.

When the boundaries of the life zones and areas are accurately mapped, the agriculturist need only ascertain the faunal area to which a particular crop or garden plant of limited range belongs in order to know beforehand just where it may be introduced with every prospect of success, soil and other local modifying influences being suitable; and, in the case of weeds and of injurious and beneficial mammals, birds, and insects, he would know what kinds were to be looked for in his immediate vicinity, and could prepare in advance for noxious species that from time to time suddenly extend their range. Persons living within the area likely to be invaded could escape by planting crops not affected, while those living outside might largely increase their revenues by giving special attention to the cultivation of the crops that are affected in the adjacent life zone.² In short, a knowledge of the

¹A review of the work undertaken and of the results accomplished by the Division of Ornithology and Mammalogy.

²This prediction was made in the annual report of the Ornithologist for 1888 (pp. 482-483), and has been recently verified in a most gratifying manner. The distribution of certain noxious insects has been mapped by the Division of Entomology; the resulting areas conform to those of particular life zones as previously mapped by the Division of Ornithology. For instance, in writing of the San Jose orange scale insect, Mr. L. O. Howard states: "It may prove to be a significant fact that, although nursery stock affected by this scale has for six or seven years back been sent to all the fruit-growing regions of the Eastern States, according to our present information the scale has established itself only in regions contained within the so-called Austral life zone. Mapping the points of establishment, it is very interesting

natural life areas of the United States and of their distinctive species and crops would enable our farmers and fruit growers to select the products best adapted to their localities, would help them in their battle with harmful species, and would put an end to the present indiscriminate experimentation by which hundreds of thousands, if not millions, of dollars are needlessly expended each year.

The division has undertaken to furnish this information. When it began the study, ten years ago, little was known of the number or extent of the natural life areas of the country or of the laws limiting the dispersion of species. The faunal areas east of the Mississippi Valley had been recognized and in a general way defined, and attempts had been made to divide the country as a whole into areas of higher grade. Most zoological writers had agreed in apportioning the United States into three primary *provinces* or *regions*—an Eastern, reaching from the Atlantic to the Plains; a Central, from the eastern edge of the Plains to the Sierra Nevada and Cascade Range; and a Western or Pacific, from the latter to the Pacific Ocean—but botanical writers were at variance both as to the number and boundaries of the divisions they sought to establish. The division began by collecting all available data on the distribution of North American mammals and birds. The facts brought together were platted on maps as the first step in the investigation.

AN EXPERIMENTAL BIOLOGICAL SURVEY.

It soon became apparent, however, that in order to gain a clear conception of the facts and phenomena of distribution a careful study of the subject must be made in the field, where the actual range of mammals, birds, reptiles, insects, and plants could be ascertained and the distinctive areas contrasted. With this object in view, and with the sanction and approval of the Hon. J. M. Rusk, Secretary of Agriculture, and the Hon. Edwin Willits, Assistant Secretary, an experimental biological survey was made in the summer of 1889. The area selected was the San Francisco Mountain region in Arizona, which, because of its isolation, altitude, southern position, and proximity to an arid desert, was believed to offer unusual facilities for a successful study of the problems involved. That this expectation was more than realized

to see how accurately this distribution has been followed. * * * This fact will relieve New England fruit growers north of southern Connecticut; those inhabiting the greater portion of Pennsylvania, except in the southeastern one-fifth and a western strip; those in New York, except for the strip up the Hudson River, and the loop which comes in from the northwest and includes the counties bordering Lake Ontario on the south, as well as those inhabiting the northern portion of the lower peninsula of Michigan and all of northern Wisconsin, from any fear of this insect. Such a condition of affairs would seem almost too good to be true, but the possibility of its truth is suggested by what we know up to the present time." (Insect Life, VII, No. 4, March, 1895, p. 292.)

may be seen by reference to the report of the expedition.¹ The area of which a careful survey was made comprises about 5,000 square miles, and enough additional territory was examined to make in all nearly 12,000 square miles, of which a biological map was published.

One result of this first survey was the complete overthrow of the principal faunal areas previously recognized in the United States, and a radical change in our conception of the principles involved. In ascending the mountain a succession of climatic belts were traversed, similar to those encountered in journeying northward from the Southern States to the polar sea, and each belt was found to be inhabited by a distinctive set of animals and plants.

The more important results of the survey may be briefly summarized as follows:

(1) It was demonstrated that terrestrial mammals, birds, reptiles, insects, and plants coincide in distribution, so that a map showing the boundaries of an area inhabited by an association of species in one group serves equally well for the other groups.

(2) Seven distinct belts or zones of animal and plant life were recognized between the Desert of the Little Colorado and the summit of San Francisco Mountain: A Desert area, a Piñon belt, a Pine belt, a Canadian belt, a Hudsonian belt, a Timber-line belt (afterwards merged with the Hudsonian as a subdivision), and an Arctic-Alpine area. No attempt was then made to propose a system of nomenclature for these several zones, but the important fact was recognized that they should be classed in two principal categories, a northern or Boreal, and a southern or Sonoran. The Alpine, Timber-line, Hudsonian, and Canadian were referred to the Boreal, while the Pine, Piñon, and Desert were referred to the Sonoran.

(3) On comparing the principal facts of distribution on this mountain with corresponding facts over the country at large, three important truths became apparent: (a) That the several life zones of the mountain could be correlated with corresponding zones long recognized in the eastern United States; (b) that these same zones are really of trans-continental extent, though never before recognized in the West; and (c) that the faunas and floras of North America as a whole, and, for that matter, of the Northern Hemisphere north of the tropical region, are properly divisible into but two primary life regions, a northern or Boreal, and a southern or Austral (then termed Sonoran), both stretching across the continent from ocean to ocean.

The report of the expedition was accompanied by colored maps showing in detail the geographic and vertical distribution of animals and plants on the mountain, and also by a colored provisional biological map of North America showing the general facts of distribution then available, arranged in accordance with the principles discovered in studying the San Francisco Mountain region.

¹Results of a Biological Survey of the San Francisco Mountain Region in Arizona. North American Fauna, No. 3, September, 1890.

The results of this experimental biological survey were so important and far reaching as to completely revolutionize current notions of distribution. It was perceived that the Austral as well as the Boreal elements in the fauna and flora are distributed in transcontinental belts; hence the arbitrary and irrational division of the United States into Eastern, Central, and Western "provinces" gave way before a rational system, based on a knowledge of the actual facts of distribution, which were found to conform to the general principle of temperature control early recognized by Humboldt and others.

PROVISION FOR A SYSTEMATIC BIOLOGICAL SURVEY.

Since the primary object of mapping the geographic distribution of species is to ascertain the number, positions, and boundaries of the natural life areas—areas fitted by nature for particular agricultural productions—the practical importance of the subject outweighed, if possible, its scientific interest. This was clearly set forth in the annual report of the division for 1889, and Congress was urgently recommended to enlarge the scope of the work so that the division might carry on a systematic biological survey. The work on distribution had been previously restricted to a study of mammals and birds. In compliance with this recommendation, the restriction was removed by Congress, and in 1890 the division was authorized to undertake a comprehensive investigation of the geographic distribution of animals and plants. Congress having thus in effect established a biological survey, the task of mapping the distribution of species and ascertaining the boundaries of the natural life zones was given greater prominence and has been pushed as rapidly as the means at hand permitted.

In 1890 a biological reconnaissance was made of south-central Idaho, the area covered comprising about 20,000 square miles. The zones recognized were the same as in the San Francisco Mountain Survey, except that the lowermost was absent. In the report on this expedition¹ the courses of the several zones were described and the characteristic species of animals and plants enumerated. The *Pine* or *Neutral Zone* of the San Francisco Mountain Survey was named the *Transition Zone*, and the upper division of the Sonoran was formally recognized as the *Upper Sonoran Zone*.

THE DEATH VALLEY EXPEDITION.

In 1891 the most comprehensive and thorough biological survey ever undertaken was made by the division. An area embracing 100,000 square miles, stretching from the Pacific Coast to the one hundred and thirteenth meridian and from latitude 34° to latitude 38°, was chosen as the field of operations.

¹ Report on a Biological Reconnaissance of South-Central Idaho. North American Fauna, No. 5, July, 1891.

This area comprises the greater part of southern California and Nevada, southwestern Utah, and the northwestern corner of Arizona, thus including all of the torrid desert valleys and ranges between the Sierra Nevada and the Colorado Plateau. It embraces also the highest and lowest lands within the United States—from Death Valley, nearly 500 feet below the level of the sea, to the lofty snow-capped peaks of the high Sierra, culminating in Mount Whitney at an altitude of nearly 15,000 feet. The region was selected because of the exceptional advantages it offered for studying the distribution of animals and plants in relation to the effects of temperature and humidity at different altitudes. The close proximity of desert valleys and lofty mountains brings near together species which in a more level country are characteristic of widely remote regions. Thus, in one place on the east side of the Sierra all of the life zones of North America, from the table-land of Mexico to the polar sea, may be crossed in a distance of only 10 miles.

The expedition, which came to be known as the Death Valley expedition, determined the distinctive species of each zone, traced the courses of the several zones from California to the Colorado Plateau, and made large collections of the mammals, birds, reptiles, insects, and plants, which are now deposited in the United States National Museum. One of the special objects of the expedition, and one early accomplished, was the location of the northern boundary of the Lower Sonoran Zone, a matter of considerable importance, because it marks the northern limit of successful raisin production and of profitable cultivation of cotton and several "subtropical" fruits. The valleys and deserts of this zone were determined from a study of the native animals and plants, and were enumerated in the annual report of the division for the same year (1891).¹ The results of this biological survey fill three volumes, two of which have been published and distributed;² the third has not yet gone to press.

CORRELATION OF THE LIFE ZONES.

A sufficient body of facts had now been brought together to justify a more comprehensive treatment of the subject than had before been possible. Therefore, in the spring of 1892 the writer published an essay on "The geographic distribution of life in North America, with

¹ The valleys and deserts of the Lower Sonoran Zone in California, Nevada, and Utah are: In California, the San Joaquin Valley, the whole of the Mohave and Colorado deserts, the San Bernardino, San Gabriel, and Santa Ana valleys, and the coast region to the southward except the mountains, the southern end of Owens Valley, Saline, Salt Wells, Panamint, and Death valleys; in Nevada, the Amargosa Desert, Pahrump, Indian Springs, Vegas, Ivanpah, and Virgin valleys; and in Utah, the St. George or lower Santa Clara Valley. (Rept. Ornith. and Mam. for 1891, p. 270.)

² North American Fauna, No. 7, May, 1893; and Contributions from the United States National Herbarium, Vol. IV, November 29, 1893.

special reference to the mammalia."¹ In this essay the continuity of all the zones, *Austral* as well as *Boreal*, was clearly established, tables of distinctive species were published, and the actual courses of the zones were shown on a colored map—the author's second provisional biogeographic map of North America. The following statement was made respecting the affinities and transcontinental character of the several zones and areas:

The time has now arrived when it is possible to correlate the Sonoran zones of the West with corresponding zones in the East, as was done two years ago in the case of the *Boreal* zones, and as was intimated in the case of the Neutral or Transition Zone. It can now be asserted with some confidence, not only that the Transition Zone of the West is the equivalent of the *Alleghanian* of the East, but also that the Upper Sonoran is the equivalent of the *Carolinian* and the Lower Sonoran of the *Austro-riparian*, and that each can be traced completely across the continent. Thus all the major and minor zones that have been established in the East are found to be uninterruptedly continuous with corresponding zones in the West, though their courses are often tortuous, following the lines of equal temperature during the season of reproduction, which lines conform in a general way to the contours of altitude, rising with increased base level and falling with increased latitude.

The zones were segregated into the two great transcontinental regions—*Boreal* and *Sonoran*²—that had been recognized two years previously, except that the Transition Zone was allowed to stand between the two without being referred to either. This latter action was criticised on the ground that it was illogical to interpose a belt of minor rank between two major regions, although it was conceded that the belt was one in which northern and southern types overlap. At the same time its affinities with the *Austral* seemed closer than with the *Boreal*, and it was afterwards allowed to go with the former, as its northernmost subdivision. The arid and humid subdivisions of all of the southern or *Austral* zones were recognized and shown on the map.

RECENT FIELD WORK.

In 1892 the northern boundary of the Lower Sonoran Zone was traced from New Mexico eastward across Texas, Indian Territory, and Arkansas to the Mississippi River, and sporadic field work was done in other States.

¹Presidential address before the Biological Society of Washington, delivered February 6, 1892. <Proc. Biol. Soc. Wash., Vol. VII, April, 1892, pp. 1-64, with colored map.

²The term "*Sonoran*" was still used for the *Austral* element in the fauna and flora which enters the United States from the table-land of Mexico, to avoid the introduction of a new name, the consideration of the nomenclature of the zones and regions being purposely deferred. The next year, however, the term "*Austral*" was formally used for this region, and the term "*Sonoran*" was restricted to its arid or western division. The first public use of the word "*Austral*" in the sense of a primary life region, was on the models and maps accompanying the exhibit of the Division of Ornithology at the World's Fair at Chicago in May, 1893, and in the annual report of the division for the same year (p. 228).

In 1893 a biological reconnaissance was made of Wyoming, a large part of which was found to be from 1,000 to 3,000 feet lower than represented on current maps, and consequently to have a warmer summer climate than was supposed, and to belong to the Upper Sonoran instead of the Transition Zone. The Wind River and Big Horn basins and the plains east of the Big Horn Mountains were found to be Upper Sonoran. Other work was done on the Great Plains in Kansas, Nebraska, and the Dakotas, and also in Utah, and on the table-land of Mexico.

During the year now drawing to a close (1894) a biological reconnaissance was made of the larger part of Montana, with special reference to the determination of the boundary between the Upper Sonoran and Transition zones. Other work was done in South Dakota and in the plateau region of Arizona. In the latter region two sections were run from the plateau southward to the Lower Sonoran deserts.

THE SEVEN LIFE ZONES OF NORTH AMERICA.

In the annual report of this division for 1893 the seven life zones of North America, including the tropical, were characterized with special reference to eastern North America, and some of the more important crops adapted to each were mentioned. Beginning at the north, these zones may be described as follows:

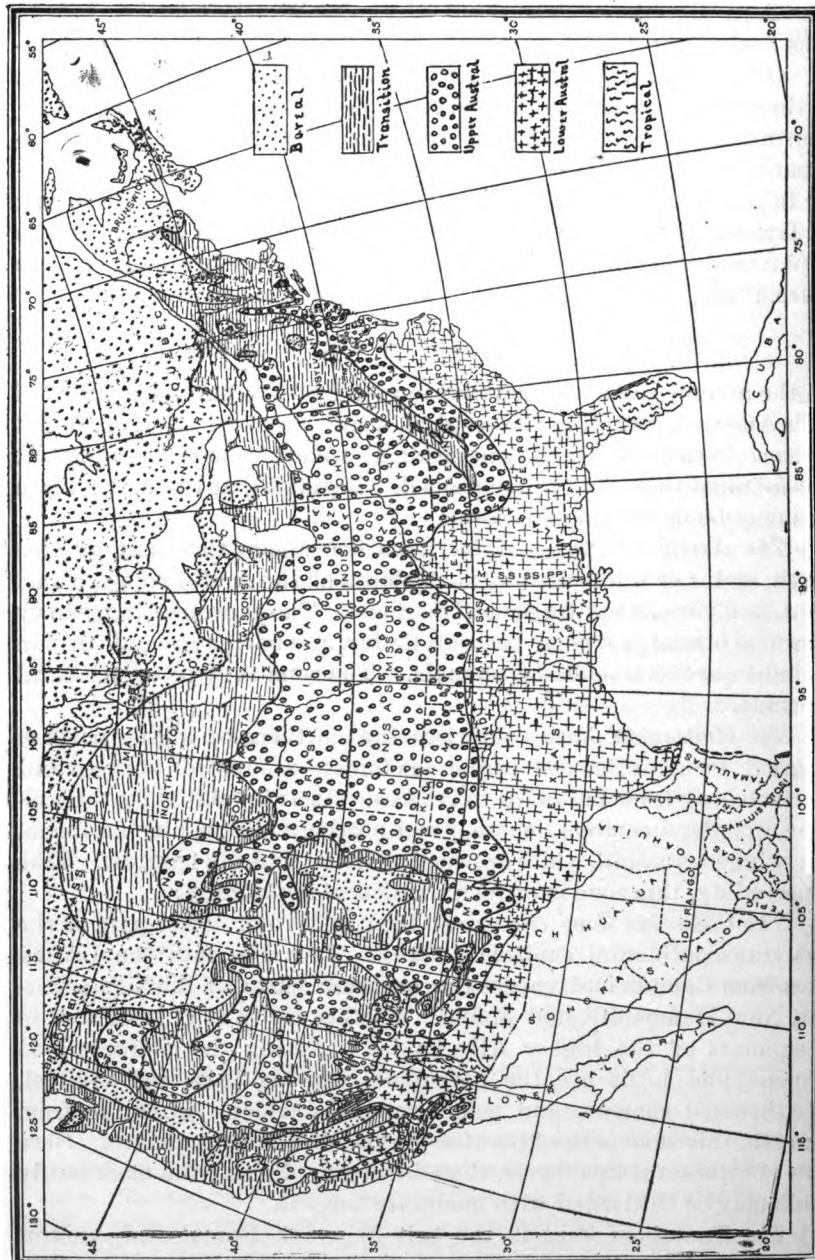
(1) *The Arctic or Arctic-Alpine Zone* lies above the limit of tree growth, and is characterized by such plants as the Arctic poppy, dwarf willow, and various saxifrages and gentians. The snow bunting, snowy owl, white ptarmigan, polar bear, arctic fox, and barren-ground caribou or reindeer are characteristic animals. The zone is of no agricultural importance.

(2) *The Hudsonian Zone* comprises the northern or higher parts of the great transcontinental coniferous forest—a forest of spruces and firs, stretching from Labrador to Alaska. It is inhabited by the wolverine, woodland caribou, moose, great northern shrike, pine bullfinch, white-winged crossbill, white-crowned sparrow, and fox sparrow. Like the preceding, this zone is of no agricultural importance.

(3) *The Canadian Zone* comprises the southern or lower part of the great transcontinental coniferous forest. It comes into the United States from Canada and covers the northern parts of Michigan, Vermont, New Hampshire, and Maine. Farther south it is restricted to the summits of the higher Alleghanies. Among the characteristic mammals and birds are the porcupine, varying hare, red squirrel, white-throated sparrow, and yellow-rumped warbler. Counting from the north, this zone is the first of any agricultural consequence. Here white potatoes, turnips, beets, the Oldberg apple, and the more hardy cereals may be cultivated with moderate success.

(4) *The Transition Zone* is the belt in which Boreal and Austral elements overlap. It covers the greater part of New England, New York, Pennsylvania, Wisconsin, and southern Michigan, and pushes

south along the Alleghanies to extreme northern Georgia. Here the oak, hickory, chestnut, and walnut of the south meet the maple, beech, birch, and hemlock of the north. The same overlapping is found among the mammals and birds, for the southern mole and cottontail rabbit,



the oriole, bluebird, catbird, thrasher, chewink, and wood thrush live in or near the haunts of the hermit and Wilson's thrushes, solitary vireo, bobolink, red squirrel, jumping mouse, chipmunk, and star-nosed

mole. In this zone we enter the true agricultural part of our country, where apples (Oldberg, Baldwin, Greening, wealthy, seek-no-farther, and others), blue plums, cherries, white potatoes, barley, and oats attain their highest perfection.

(5) *The Carolinian Zone* covers the larger part of the Middle States except the mountains; on the Atlantic coast it reaches from near the mouth of Chesapeake Bay to southern Connecticut, and pushes still farther north in the valleys of the Hudson and Connecticut rivers. It is the region in which the sassafras, tulip tree, hackberry, sweet gum, and persimmon first make their appearance, together with the opossum, gray fox, fox squirrel, cardinal bird, Carolina wren, tufted tit, gnatcatcher, and yellow-breasted chat. In this zone the Ben Davis and wine-sap apples, the peach, apricot, quince, sweet potato, tobacco, and the hardier grapes (such as the Concord, Catawba, and Isabella) thrive best.

(6) *The Austroriparian Zone* covers the greater part of the South Atlantic and Gulf States, beginning at the mouth of Chesapeake Bay. The long-leaved pine, magnolia, and live oak are common on uplands, and the bald cypress and cane in swamps. Here the mocking bird, painted bunting, red-cockaded woodpecker, and chuck-wills-widow are characteristic birds, and the cotton rats, rice-field rats, wood rats, little spotted skunks, and free-tailed bats are common mammals. This is the zone of the cotton plant, sugar cane, rice, pecan, and peanut; of the oriental pears (Le Conte and Kieffer), the Scuppernong grape, and of the citrus fruits—the orange, lemon, lime, and shaddock. In its western continuation (the Lower Sonoran) the raisin grape, olive, and almond are among the most important agricultural products, and the fig ripens several crops each year.

(7) *The Tropical Region*, within the United States, is restricted to southern Florida, extreme southeast Texas (along the lower Rio Grande and Gulf coast), and the valley of the lower Colorado River in Arizona and California. Among the tropical trees that grow in southern Florida are the royal palm, Jamaica dogwood, manchineel, mahogany, and mangrove; and among the birds may be mentioned the white-crowned pigeon, Zenaida dove, quail doves, a Bahaman vireo, Bahama honeycreeper, and caracara eagle. The banana, cocoanut, date palm, pineapple, mango, and cherimoyer thrive in this belt.

FUNDAMENTAL PRINCIPLES OF ANIMAL AND PLANT DISTRIBUTION.

It now remains to discuss the causes of distribution, or rather the causes, other than absolute geographical barriers, that restrict species to definite areas or belts.¹ The fact has been long recognized—since the time of Humboldt at least—that animals and plants are not universally distributed over the earth, but disappear along certain more or less definite lines, which lines indicate a change in temperature uncongenial

¹ By permission of the Hon. J. Sterling Morton, Secretary of Agriculture, a preliminary announcement of the "Laws of temperature control of the geographic distribution of terrestrial animals and plants" was published in the National Geographic Magazine, Vol. VI, December 29, 1894, pp. 229-238, illustrated by 3 colored maps.

to the species; but exactly what temperatures exert the controlling influence, and how they can be measured, have only recently been discovered. Until the past year the mistake was made of assembling all the temperature data in accordance with a single hypothetical law. Then a radically different plan was tried: The temperature data were plotted in accordance with two widely different principles—one with reference to the northern, the other the southern, boundaries of the zones. This departure was suggested by a somewhat tardy recognition of the fundamental facts of distribution discovered in 1889, namely, that animals and plants are themselves distributed from two directions—Boreal species from the north, and Austral species from the south. It seemed reasonable to infer, therefore, that northward distribution should be governed by one set of temperatures, and southward distribution by another. The temperature selected as probably fixing the limit of northward distribution is the sum of effective heat for the entire season of growth and reproduction, for it has been proved experimentally and long recognized by phenologists that many species of plants require a definite sum total of heat in order to successfully perform the several vital functions of leafing, blossoming, and fruiting, and that such plants can not mature their seeds until a particular sum of heat is attained. Since plants are unaffected by temperatures below and immediately above the freezing point, a minimum of 6° C. or 43° F. was assumed to represent the inception of the period of physiological activity in spring, and hence was used as a starting point in adding the normal daily temperatures for the entire period in question. Beginning at 43° F., all mean daily temperatures in excess of this were added together, the end of the period in fall being the time when the temperature fell to the same initial point. In this way it became possible to ascertain the total quantity of heat required for each species experimented upon.

When the sums of the positive temperatures for a large number of localities in the United States were plotted on a large scale map it was found that isotherms (lines showing an equal quantity of heat) could be drawn that correspond almost exactly with the northern boundaries of the several zones. In the case of the southern boundaries a greater difficulty was encountered, for no data had been published bearing on the temperature control of southward distribution. At the same time it seemed evident, from data previously collected by the division, that species are limited in their southward distribution by the mean temperature of a brief period during the hottest part of the summer. For experimental purposes the mean normal temperature of the hottest six consecutive weeks of summer was assumed to be the factor desired, and this temperature was plotted for a large number of localities. Isotherms were then drawn which marked the southern boundaries of the several zones along the Atlantic coast, and it was found that in ranging westward these isotherms conformed throughout to the tortuous boundaries of the Boreal, Transition, and Upper Austral zones, previously mapped from a study of the actual distribution of animals and plants.

While it is not for a moment supposed that the subject has been disposed of in all its details, it is confidently believed that the principles controlling the geographic distribution of terrestrial animals and plants have been discovered and that they may be expressed as follows:

In *northward* distribution terrestrial animals and plants are restricted by the sum of the positive temperatures for the entire season of growth and reproduction.

In *southward* distribution they are restricted by the mean temperature of a brief period during the hottest part of the year.

It is believed that these two principles cover the fundamental facts of distribution.

RECAPITULATION.

When the division undertook the study of the geographic distribution of life in North America, the transcontinental or zonary character of the principal life areas was not recognized, and the laws governing distribution were unknown. Zoologists and botanists had always worked independently; the maps each had published differed radically among themselves, and no agreement could be found between the two series. The divisions commonly adopted by zoologists were three—an Eastern, a Central, and a Western or Pacific province or region. In addition to these, some authors had recognized a transcontinental Boreal region, which was clearly shown on a map published by Dr. A. S. Packard in 1878.¹

The first biological survey undertaken by the division (in 1889) established the important facts that the same laws govern the distribution of both animals and plants, and that the resulting areas of distribution are essentially coincident. It showed also that the life areas of North America and of the Northern Hemisphere as a whole take the form of a definite number of circumpolar or transcontinental belts, and that these belts or zones naturally arrange themselves in two principal categories or regions—a northern or Boreal and a southern or Austral.

The work accomplished by the division up to the present time may be briefly summarized as follows: The continent of North America has been divided into three primary life regions—Boreal, Austral, and Tropical—each of transcontinental extent. Their boundaries are sinuous, conforming to the distribution of temperature.

The *Boreal Region* stretches from Nova Scotia and Newfoundland westward to the Pacific Ocean, and from northern New England and the Great Lakes northward to the pole and southward over the pri-

¹Dr. Packard's map was a decided advance over those of his predecessors, inasmuch as it showed the Boreal region to extend southward over the three great mountain systems of the United States—the Alleghanies, Rocky Mountains, and Sierra-Cascade. The remainder of North America, as shown on Dr. Packard's map, was divided between the three commonly recognized regions above mentioned—the eastern, central, and western or Pacific—to which were added on the south a Central American region and an Antillean region.

cipal mountains of the United States and Mexico. It is subdivided into three principal belts or zones, Arctic, Hudsonian, and Canadian. (1) The Arctic or Arctic-Alpine belt comprises Arctic America above the limit of tree growth, including Greenland and a narrow strip along the coast of Labrador and Newfoundland, and also the summits of the higher mountains above timber line throughout the United States and Mexico; (2) the Hudsonian Zone embraces the northern half of the great coniferous forest that reaches across the continent from Labrador to Alaska; (3) the Canadian Zone embraces the southern half of the great coniferous forest, stretching westward from northern New England and Nova Scotia to British Columbia.

The *Austral Region* is likewise subdivided into three transcontinental zones: (1) A Trausition Zone; (2) an Upper Austral Zone; (3) a Lower Austral Zone, all stretching from the Atlantic to the Pacific and winding about sufficiently to cover areas of equal temperature. Each of the three Austral belts may be subdivided in an east and west direction into two or more areas, some of which are based on humidity instead of temperature. The eastern ends of these three belts have been long recognized by zoologists, and are known as the Alleghanian, Carolinian, and Austroriparian faunas. It was early shown by the division that the Austroriparian is the direct continuation of the arid Lower Sonoran fauna of the table-land of Mexico and the southwestern United States, and that this same faunal belt occupies the interior valley of California and most of the peninsula of Lower California.

The *Tropical Region* comprises Central America, the greater part of the coastal lowlands of Mexico, and the Antilles. It enters the United States at three points, southern Florida, the lower Rio Grande region in Texas, and the valley of the lower Colorado River in western Arizona and southeastern California.

The various zones have been studied in the field by the division and their boundaries located and mapped over extensive areas.

Summary.—The principles of geographic distribution of terrestrial animals and plants in the Northern Hemisphere were clearly recognized in 1889; the correlation of the life zones was completed in 1892; the laws of temperature control were formulated in 1894. The work remaining undone relates to details and may be classed under four heads: (1) Completion of the boundary surveys of the several zones; (2) subdivision of the zones into minor faunas and floras; (3) tabulation of the distinctive species of each zone and its subdivisions; (4) formulation of the subordinate laws governing the restriction of species to particular areas within the principal zones.

It appears, therefore, that in its broader aspects the study of the geographic distribution of life in North America is completed. The primary regions and their principal subdivisions have been defined and mapped, the problems involved in the control of distribution have been solved, and the laws themselves have been formulated.



3 2044 106 203 0

Date Due

AUG 1973

